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PRACTICAL TEXT CONCEPT MAPPING: NEW PEDAGOGY, NEW TECHNOLOGY

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Abstract. Previous experimental studies have indicated that young people's text comprehension and summarisation skills can be improved by techniques based on text concept mapping (TCM). However, these studies have done little to elucidate a pedagogy that can make the techniques adoptable within the context of typical secondary school classrooms. This paper explains how a collaborative research approach has developed a new pedagogy, named TCM/4, for text concept mapping, along with new technology that supports this pedagogy in practical ways. Case studies indicate that pupils enjoy their lessons and share their teachers' opinion that TCM/4 is helpful in learning to comprehend texts.

1 Introduction

Development of literacy skills is a major goal for education in all countries. According to the UK's National Literacy Trust (2006), one in four adults in the developing world is illiterate. In England, 16% of the adult population has reading skills at or below the level expected of 11-year olds in the National Curriculum. Poor basic skills cost UK industry more than £4.8 billion a year and also represent a personal tragedy for individuals. About 50% of jobs are closed to someone who only has the minimum level of basic skills. Shifting economic trends will increase the disadvantage, with forecasts suggesting that by 2009, only 21% of UK jobs will fall into the 'elementary and operative' categories.

For children in school, a high proportion of information is presented in the form of text and hence weak literacy is a major barrier to learning. This project is focussed upon an important area of text literacy skills, specifically the area of text comprehension, and upon the use of concept mapping to support learners' summarisation of texts. The paper is in six parts. In part 2, we explain why this type of work seems to be promising in the light of previous research. Part 3 explains how the present research was stimulated by the perception of a wide gap between research and practice in secondary schools in our local area. The core of the paper is part 4, which describes our research goals and methods, including reports of case studies that we have undertaken to develop and evaluate new pedagogy and technology. Part 5 discusses some key issues that seem to be raised by this project and finally, part 6 provides a conclusion.

2 Previous research

2.1 Seminal

The seminal book by Novak and Gowin (1984) discussed the use of concept mapping as a learning activity. Among the applications identified was that learners could use concept mapping as an aid to comprehending a text. Nowadays, a recognised shorthand for this overall approach is 'text concept mapping' (TCM). The rationale for TCM seems straightforward: a learner faced with the task of transforming a text into a concept map is necessarily engaged in the selection of main concepts, organisation of these concepts into related categories, and their reintegration into a structure of meaningful propositions. This amounts to summarising, and hence presumably comprehending, the text. Because it can make important relationships explicit, concise, and memorable, the concept map that emerges from the text may act in several ways to support learning — it provides a salient record of work done, an organiser for parts of the text not yet processed, and a tool supporting communication with teachers and fellow students.

2.2 Experimental studies

Experimental studies have tended to endorse the value of TCM and significantly, some have demonstrated that the benefits can transfer beyond the learning of the specific texts that are mapped. An example is Chmielewski and Dansereau's (1998) study of 60 undergraduate students. This study concluded that training in TCM improves a person's *underlying* information-processing strategies and skills, a result that its authors observe to be "encouraging given the sparsity of far transfer effects that has been documented in the literature over the past 50 years" (op. cit., p412).

A second example comes from the study by Chang, Sung and Chen (2002) who compared three different versions of TCM. In a seven-week course, 126 Taiwanese fifth-grade pupils (mostly aged 10) were formed into

three groups and each provided with the same set of specimen texts. The first group corrected maps that had been wholly preconstructed but in ways that deliberately included errors; the second group completed maps that were partly and accurately preconstructed; and the third group generated maps in *tabula rasa* fashion. This study found that children in the first two groups improved their comprehension and summarisation skills in ways that were manifest beyond the completion of the course, even in situations which made no explicit use of TCM. The third group showed no more improvement than a control group, a finding that was attributed to the over-demanding nature of *tabula rasa* map generation and the inadequacy of the children's initial training.

A third study, conducted by Nathan and Kozminsky (2004) in Israel over one entire school year, repeatedly tested 112 eighth-graders (age 14) on their language, concept mapping, comprehension, and writing skills. In the first semester some students used a TCM technique while others did not. In the second semester all students conducted collaborative research projects. Results indicated an advantage for the TCM students both after the first semester and at the end of the year. The version of TCM adopted in this study was notably elaborate: it contained five stages of activity, from pre-mapping prior to reading the text through to review of final maps. Perhaps unsurprisingly, the researchers observed that the method "may tax students with learning difficulties, or less skilled mappers".

3 From research to secondary school practice

The present study originates in an informal network of Scottish teachers and researchers who shared an interest in concept mapping, in particular TCM. The network has a core of about a dozen individuals, with peripheral participation that at various times has been much greater. Teachers from MEd (Chartered Teacher) courses, teachers from local secondary schools who are engaged in teacher education roles, university staff from education and informatics faculties, and students on BEd and PGDE teacher education programmes, have all played active parts. Our research agenda has three parts: to demonstrate a practically effective pedagogy for TCM within our local contexts, specifically those of Scottish secondary schools; to develop technology that would support classroom use of TCM; and to begin to explore some of the factors which seemed to have been neglected in existing research.

Such a research agenda acknowledges that TCM is not part of the current practice of Scottish classroom teachers. In fact, one of our earlier studies found that within a large and well-regarded local secondary school, concept mapping was hardly used for any purpose whatever and only some very limited use of mind-mapping was identified (Conlon & Bird 2004). The gap between research and practice is clearly wide. Unfortunately, almost all existing TCM studies have been conducted not by teachers but by academic researchers. They were also based in curricular and cultural contexts that are, to us, unfamiliar. Thus, the teachers in our network faced a large challenge in discovering how TCM might be successfully adopted in their typical classrooms, assuming the approach was practically adoptable at all.

A particular challenge to our project was that there existed no standard technology for TCM. Although numerous software tools for concept mapping are available, few if any have been designed to match the specific needs of TCM and its associated pedagogies. A weak relationship between technology and pedagogy is not unusual, unfortunately: one influential review of UK school technology initiatives concluded that 'ICT in the curriculum has been broken-backed without a pedagogical spine to provide the necessary structure and support' (Reynolds et al., 2003).

4 Research methods and implementation

The research agenda outlined above shaped our main project goal: to investigate ways in which TCM might be practically adapted towards, and sustainably adopted within, Scottish secondary schools. Our emphasis on practical and sustainable development is influenced by Hargreaves' (2003) advocacy of curriculum development as something that must be led by 'professional learning communities' as opposed to 'performance training sects'. The rationale for our project is not to repeat existing experimental studies, nor merely to 'transfer' them, but rather to support teachers in transforming the knowledge from those studies in a process of shared enquiry based on their own specific contexts, with a view to developing new pedagogical practice where that seems to be justified by emerging evidence.

Our underlying research methods are correspondingly practice-oriented and collaborative. They are based on a theoretical research approach known as PCM (Persistent Collaboration Methodology; Conlon & Pain

1996), a hybrid of traditional action research with a participative-design approach to the development of pedagogy and associated technology. PCM is similar to action research in that it employs an iterative cycle containing phases of reflection, design, implementation and observation. It differs from much of action research by its assumption that, if the aim is to generate well-integrated and well-theorised pedagogy and technology, then what is required is a well-organised collaboration of researchers, teachers and technologists. PCM identifies the roles and outcomes of such a collaboration. We were fortunate in having access to a network that made this research approach feasible.

4.1 Stage 1: Framing the problem

In the first stage of research, discussions were held with a group of experienced secondary teachers, all of whom were working on a specialist concept mapping course that contributed towards their 'chartered teacher' qualification. For curriculum focus, an initial target group was suggested of Higher Grade (age 16-17) students using texts accessed from the government-sponsored Scholar website (http://scholar.hw.ac.uk). Scholar provides numerous study texts for a variety of subjects and it is widely used by teachers in Scotland to promote forms of independent learning, including home learning (Livingston & Condie 2004). The teachers in our group believed that students' weak text comprehension skills limited the usefulness of Scholar, making this a relevant (as well as fairly safe) initial testbed for TCM.

In terms of pedagogy, the various strategies for TCM as documented in the research literature were considered by our group to each combine possible strengths with weaknesses. Table 1 summarises the lengthy discussions that took place. In general, the documented strategies were regarded as too contrived or elaborate for adoption in normal classrooms. The overall preference that emerged from discussion was for a relatively simple strategy comprising four phases, as shown in Table 2. For convenience of referencing, we have named this strategy 'TCM/4'. Although essentially a map generation approach, TCM/4 is relatively novel in combining concept mapping with explicit phases of skim-reading, colour highlighting, and reflection: these were elements of pedagogy with which teachers were already familiar and which had proved successful in their previous experience. This embedding of concept mapping within an overall pedagogy that included other, already trusted, methods seemed to increase teachers' confidence, boost the prospects of the strategy, and mitigate the risks associated with a new approach to learning.

TCM strategy	**Reference**	**Possible strengths**	**Possible weaknesses**
Correction approach: students correct maps that have been preconstructed, with errors introduced	Chang, Sung & Chen (2002)	• Closed task, easily managed by teachers • Easily assessed • 'Problem-solving' approach	• Extensive teacher preparation required • May undermine aim of truly independent student study • Too little challenge for stronger students
Scaffolding approach: students complete maps that have been partly (and accurately) preconstructed	Ditto	• 'Scaffolding' idea is familiar to teachers • Adaptable to suit learners at different stages	• Extensive teacher preparation required • May undermine aim of truly independent student study
Generation approach: students generate maps from scratch	Ditto	• No prior maps required, easing teachers' preparation • Consistent with aim of independent study • Flexible — can be applied to any text	• Too much challenge for weaker students • Open task, may be difficult for teachers to manage • Difficult to assess
Multiple-stage approach: pre-mapping, drafts, final maps with reviews	Nathan & Kozminsky (2004)	• Starts from what students already know	• Requires extensive teacher input • Highly effortful for students — some resistance anticipated

Table 1 **Evaluation of documented variants of TCM strategy**

Phase	Activity	Aim
1	Skim-reading	Quickly browse the text for gist
2	Highlighting	Close-read the entire text, highlighting key words and phrases using colour markup
3	Concept mapping	Build concept map using highlighted words and phrases
4	Reflecting, reviewing and refining	Compare concept map's contents to original text and refine as necessary for an accurate summary of the required length

Table 2 **TCM/4: The four-phase strategy for TCM favoured by our research network**

4.2 Stage 2: Developing technology

At an early stage, formative trials of TCM/4 were undertaken with BEd and PGDE students using technology based on our existing Conception mapping system. These identified the need for at least two technology developments. First, in order to support phases 2 and 3 of the TCM/4 strategy, a new text markup tool was specified that would be fully integrated within Conception. This tool would enable colour highlighting and also provide a command for copying marked-up text into list windows, from which phrases could be transferred into a concept map window by drag-and-drop. Second, to support phase 4, a sentence generation tool which extracted sentences from the concept map window seemed necessary. Such a tool could encourage learners to ask of themselves questions useful to formative assessment, such as: Do these sentences represent an accurate summary of the original text? Do they capture the text's most important ideas?

We implemented these tools (which are now part of the Conception package, available from www.parlog.com — see also http://www.parlog.com/pub/files/Appendices1-8.pdf for screenshots and other illustrative project material) and tested them in further laboratory-based trials. Significant refinements followed. For instance, observations of students showed that they tended generally to over-markup their text, leading to dense concept maps and, in many cases, to summaries of text that did not necessarily select the most important elements of content. To address this difficulty, we implemented a status field that continuously indicates how much of the text has been marked up, together with limits on the quantity and length of markups that will be permitted before the software protests. These markup parameters are user-settable: in practice we hoped that teachers would recommend values to suit the particular target text and the required length of summary.

4.3 Stage 3: Classroom case study — upper-school Computing

The first episode of classroom-based research was located within a Scholar-using Computing department in a local comprehensive school. This department's teachers had been using concept mapping and Conception software with pupils for several years. Adam Caldwell, the teacher of the Higher Computing class (comprising seventeen pupils from secondary fifth-year, ages 16-17), volunteered to lead a case study that would contribute to an evaluation of TCM/4. In an initial interview, he made clear his disappointment in pupils' typical levels of learning from Scholar texts hitherto.

In a seventy-minute lesson observed by a researcher, Adam presented the class with a previously unseen Scholar text on Computer System Performance, a topic that they had been studying as part of their Computing Higher course. The text was technical and descriptive, 1180 words long, and measured at grade 11.2 on the Flesh-Kincaid readability scale. Almost all pupils had used forms of concept mapping (but not TCM) in previous classes. Adam had introduced to them the phases of TCM/4 and the associated Conception technology in a one-hour lesson a week prior to the observed lesson.

The observed lesson began with Adam explaining that the pupils' task was to read the Scholar text and create from it a concept map summary containing no more than 30 nodes, refining the map until they were happy that it generated sentences that comprised a valid summary. It was evident to the researcher that pupils mainly understood what was involved in the TCM/4 process and they were highly attentive to their task throughout the lesson. In line with Adam's normal practice, pupils worked individually and with only occasional interaction. All were still working on their 'first-draft' concept map when the lesson ended. The next day they worked for a further hour in refining and reviewing their maps, by the end of which time about half of them considered that they had completed the task. Table 3 summarises the researcher's and teacher's shared observations.

Phase	Ave. time spent	Observations
Skim-reading	10 minutes	Direct reading of the text from a Scholar web page. All pupils were attentive.
Highlighting	15 minutes	A file containing the text in a Conception markup window was created without difficulty. Some pupils highlighted only concepts, others highlighted both concepts and relationships.
Concept mapping	45 minutes (to first draft map)	Transfer of highlighted text to list windows caused no problems. Drag-and-drop from there into the concept map window was normal practice. Pupils frequently cross-referred between the markup window, the list window(s) and the concept map window, managing this process well.
Refining and reviewing	60 minutes	Sentence generation seemed an effective stimulus to map review, but weak expressions were sometimes not improved in the redrafting.

Table 3 **Higher Grade pupils' progress through the phases of TCM/4**

In discussions that followed, Adam said that he was encouraged by this first experience of TCM/4. He predicted that further work would confirm TCM/4 to be a valuable complement to Scholar and one that his departmental colleagues would be keen to adopt. When asked to predict obstacles to adoption by other departments in his school, Adam suggested that the two main ones would be teachers' lack of access to technology and their lack of available time to learn the new methods.

A review of pupils' completed concept maps was conducted. Some demonstrated impressive performances in the task, but others clearly revealed a restricted grasp of subject matter, poor comprehension, or in a few cases, weak skills in concept mapping. Pupils' own written feedback mostly indicated agreement that TCM/4 had helped them to learn the information from the Scholar text and they concurred that the strategy should be adopted in other subjects too. However, a few said that TCM was too time consuming, not enough fun, or suited only to people with particular learning styles.

4.4 Stage 4: Classroom case study — lower-school English

The above case study of a Higher Computing class demonstrated the practicality of TCM/4 within the particular context of technically-oriented pupils who were upper-school, relatively high-achieving, and well-motivated. In our second trial, we aimed to test the approach within a very different, and in some ways more typical, context for learning in literacy: specifically, lower-school, mixed-ability classes within the English department of another comprehensive school.

Iain Petrie, an English teacher who had recently completed an MEd (Chartered Teacher) course in concept mapping, agreed to lead this part of the project with case studies undertaken in his first- and second-year English classes. His pupils had been working on their 'close reading' skills using factual texts and Iain was hopeful that TCM/4 might boost their learning in this area. His overall approach deliberately mirrored that of the earlier trial but with some variations to match the needs of his different contexts.

In this paper, we outline only the experience of the first-year class. This class comprised 14 pupils aged 12-13 years whose attainment levels in the Scottish 5-14 Language Curriculum ranged from A to D (the highest achievable level is F; see SOED, 1991). Iain's pupils had been using Conception, mainly to explore imaginative writing, since the start of the year. They normally worked in friendship pairs and did so throughout the lessons described here.

In the first lesson, Iain used an interactive whiteboard to demonstrate the newly developed Conception tools for text markup, list creation and sentence generation. Pupils were informally introduced to the TCM/4 process and were then allowed to explore the software freely with various, mostly factual, types of text. In the lessons that followed this introduction, pupils were asked to build a concept map that summarised an unseen factual text. The text contained 156 words and had a Flesh-Kinkaid grade of 7.1. Iain's observations on these lessons are summarised in Table 4.

Phase	Ave. time spent	Observations
Skim-reading	10 minutes	Pupils found the text reasonably accessible.
Highlighting	20-25 minutes	All pupils tried to highlight both concepts and relationships. Some software problems were noted; e.g. where highlighting areas touched, two markups become one. Increasing font size helped.
Concept mapping	60-80 minutes (to first draft map)	Transfer of highlighted text to list windows caused no problems. But pupils generally neglected drag-and-drop (and even copy-paste) from those windows into the concept map. Despite demonstration and reminders of drag-and-drop, they mostly re-keyed text instead, sometimes introducing spelling errors. Occasional software crashes caused frustration.
Refining and reviewing	80-100 minutes	Some pupils added colour to their maps as an additional means of organising information. The sentence-generation tool was mostly helpful in assisting concept map review, but some maps remained weak.

Table 4 **First-year English pupils' progress through the phases of TCM/4**

In reflecting on pupils' collaborative behaviour, Iain observed that a pattern had emerged in the pairings where the higher-attaining individuals (in terms of their pre-assessed 5-14 levels) came to dominate phases 3 and 4. Partners seemed to accept this readily, but remained active and focussed on the task. In fact all pupils were keen and eager to participate throughout and, unusually for this class, they sought and used dictionaries as they went about the task. Lack of familiarity with the software caused some problems but pupils soon reached the point of requiring little or no teacher assistance, although the time required to complete the task was longer than anticipated.

Pupils' maps varied in quality and those with weaker expression or comprehension skills tended to produce weaker maps, as Iain had expected. Pupils' own written evaluations of the experience (see Table 5 for a small sample of unedited comment) mainly confirm their enjoyment of the process and also their belief that it was helpful in understanding the text. Most pupils expressed willingness to make use of the strategy in other subjects, and also for homework, and they affirmed that it could be applied (albeit less conveniently) even without use of computer systems. Iain noticed that these lessons created interest among wider school staff, including History department members who came to observe.

	Pupil #	*Pupil's comment (unedited)*
Did the Conception mapping system help you to learn the information that was contained in the text you were asked to study?	1	Yes it helped me learn the information.
	2	Yes it did help me learn more stuff because i've never used it before
	3	Yes! Because it told you the words and you just had to type them
	4	Yes because the text was helpful on what we were going to do.
Was the software easy to use?	1	Yes I enjoyed using it.
	2	It was quite difficult at the start but when me and my partner got all the work together we started doing it easy like i would tell her ideas and she would tell me ideas and wee both would get it all together
	3	It was easy and fast
	4	It was ok opening was ok to.
Do you think the techniques used in this exercise could be completed without the use of a computer?	1	Yes because it's very simple and you could do it on paper.
	2	I think i would be able to do it but it would take longer to make it all be neat and tidy
	3	Yes ! Because you could use highlighters
	4	No

Table 5 **First-year pupils' comments**

5 Discussion and future work

In this section, we raise issues on three areas that seem central to the project: the TCM/4 pedagogy, the associated learning technology, and the research methodology.

As to the first area, evidence from the case studies suggests that TCM/4 does provide a practical pedagogy that is enjoyable for many (but not all) pupils at different stages of secondary schooling and in different subjects. However, it is both demanding on teachers' skills and time-consuming. The latter point was frequently commented upon by teachers and pupils alike. Although completion times will surely fall as pupils gain familiarity with the process, any investment of classroom time needs to be justified by learning benefits; and of those that are potentially on offer here, it is the transferable benefits (rather than the benefits of learning the specifically mapped text) that seem most promising. Unfortunately, we do not yet know what pattern of classroom episodes of the strategy is required to optimise transferable learning.

A large part of this project was concerned with the development of technology that would integrate well with the pedagogy. The extensions that we developed to the existing Conception mapping software included new tools for text-markup; for phrase extraction from marked-up text into list windows; for drag-and-drop support for transfer from list windows into a concept map window; and for sentence generation from the concept map. A clear risk in this development was that the resultant software could be too difficult for pupils to use. However, the evidence from classroom studies is that most pupils actually found it to be usable and even enjoyable. Problems certainly remain: the comments from teachers and pupils about lack of robustness, and various interface issues, need to be addressed.

In fact, there is considerable potential in our technology that has not yet been exploited. Conception has always been capable of constructing not only concept maps, but also other, more specialised types of information map, such as argument maps, decision maps, and swot maps. Previously we have justified this capability as affording a 'repertoire for teaching and learning' (Conlon & Gregory, 2007). When we designed the system's new tools, we ensured that they would accommodate other types within the repertoire beyond concept maps. The implications are promising. For instance, a discursive-type text can be marked up using the specialised semantic categories of an argument map ('claims for', 'claims against', 'grounds', etc) and summarised accordingly. Applications of this capability await investigation and, especially in this area of new opportunity, we would welcome collaboration with other researchers.

Our project is also suggestive of answers to some interesting questions about research methodology. One such question was hinted at earlier: how should the development of learning technology interact with the development of pedagogy? The PCM strategy (described previously) aims to develop the two *concurrently*, with technology emerging in the service of a coherent enriched pedagogy. Thus, the Conception-based software tools emerged synergetically with the TCM/4 pedagogy. This is a tricky research strategy but it can produce good results. Critical to its success is the right kind of collaboration between technologists, researchers, teachers and learners. Unfortunately, such collaborations (certainly in the case of UK education) are rather rare.

There remain many questions about TCM/4 that we would hope to address by future research. One already mentioned concerns the applicability of the strategy to text genres other than factual texts. Other questions that have been raised within our research network are summarised below (Table 6).

Phase	**Problems and issues**
Skim-reading	▪ How can teachers best support this phase, which at present has no 'visible trace'?
Highlighting	▪ Should relationships as well as concepts be marked-up, or concepts only? ▪ How much highlighting should be recommended for each particular text? How should Conception's 'markup limit' parameters be set? ▪ What can be done to ensure that highlighting entails 'close reading'?
Concept mapping	▪ How important are generic concept mapping skills in this phase and how best can such skills be developed?
Refining and reviewing	▪ The sentence generation tool is not always effective in stimulating learners to self-assess their summaries. How can this type of formative assessment be improved, for instance by the use of prompts or analysers?

Table 6 **Questions for TCM/4 research and practice**

6 Conclusion

This project has focussed on ways in which secondary school pupils might develop text comprehension and summarisation skills through concept mapping. The main contributions of the project are a new pedagogy, named TCM/4, and an associated new technology that is currently implemented by extensions to the Conception mapping system. The technology and pedagogy have been demonstrated to make text concept mapping enjoyable and, probably, practically adoptable across a range of curriculum contexts. Although more research is needed to refine and evaluate both pedagogy and technology, the evidence from our case studies clearly points to a promising addition to the repertoire of practical approaches to teaching and learning in literacy.

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